Feb. 14, 1956 A. G. BADE 2,734,397

MECHANICAL TYPE INFINITELY VARIABLE SPEED-CHANGING TRANSMISSION

Filed May 14, 1951 3 Sheets-Sheet 1

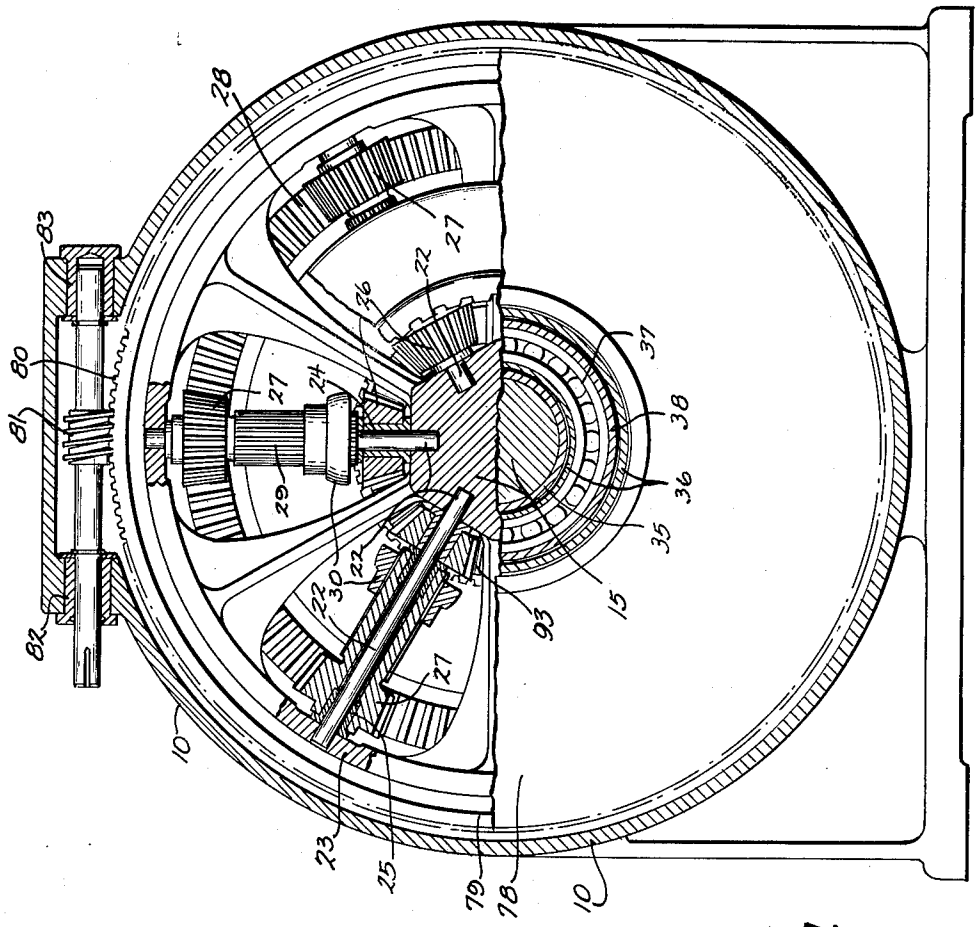


Fig. 1

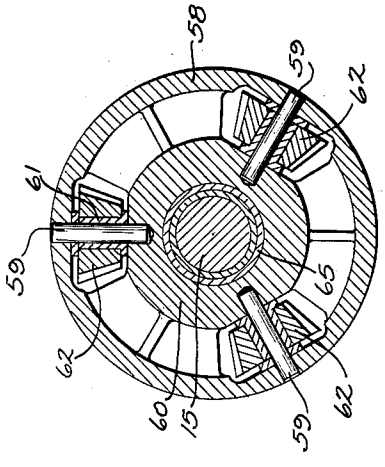


Fig. 3

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MECHANICAL TYPE INFINITELY VARIABLE SPEED-CHANGING TRANSMISSION

Filed May 14, 1951 3 Sheets-Sheet 2

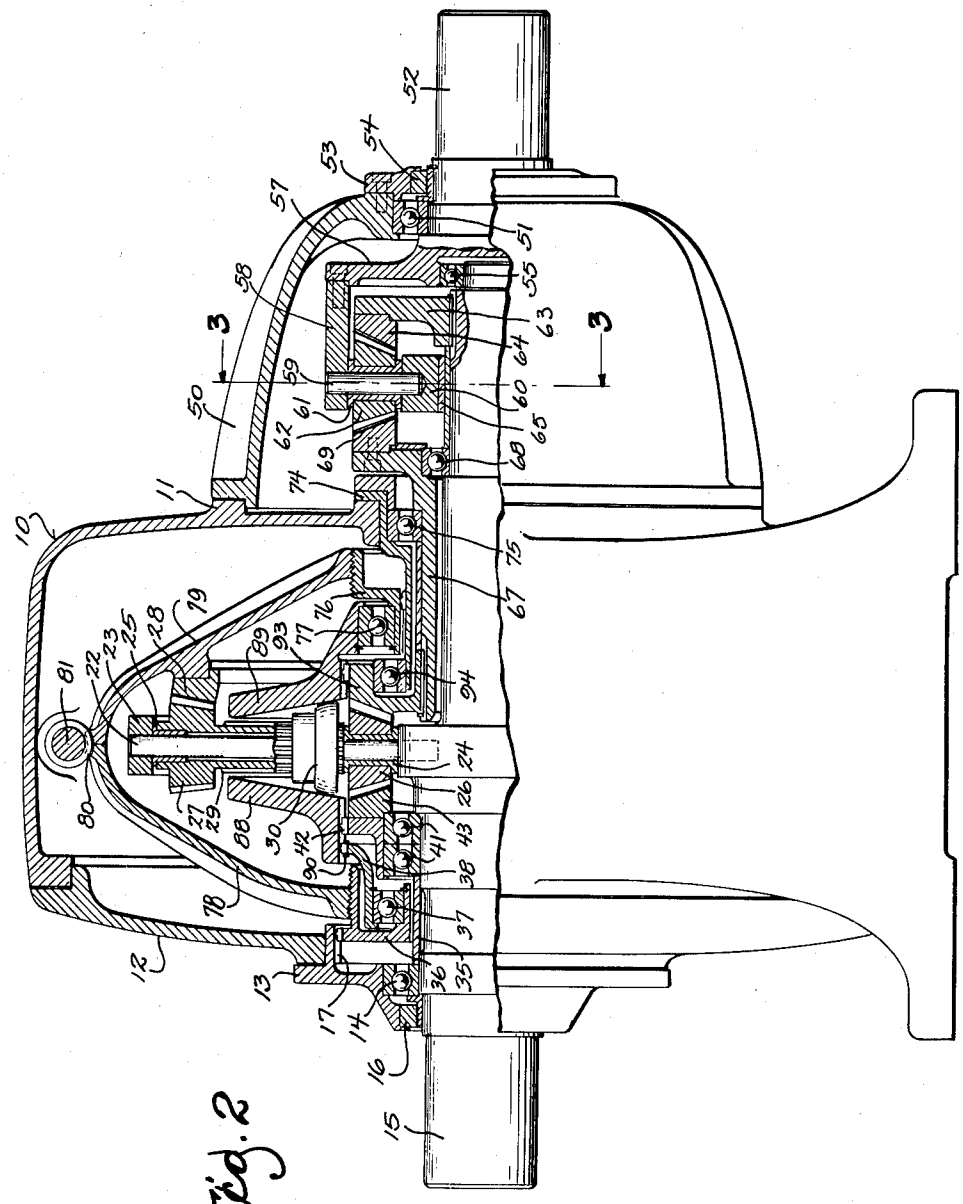


Fig. 2

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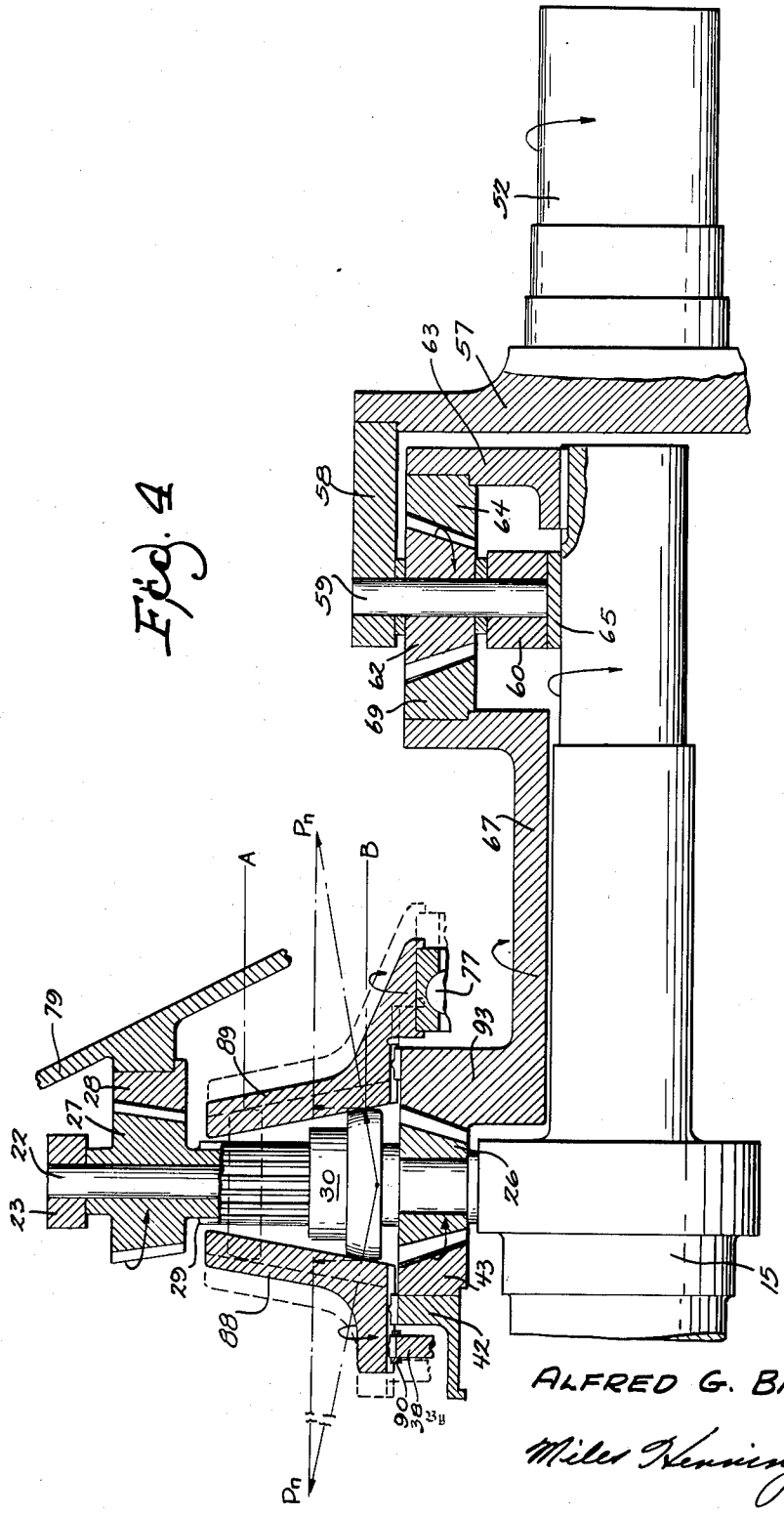
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MECHANICAL TYPE INFINITELY VARIABLE SPEED-CHANGING TRANSMISSION

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Fig. 4



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2,734,397

MECHANICAL TYPE INFINITELY VARIABLE SPEED-CHANGING TRANSMISSION

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Application May 14, 1951, Serial No. 226,162

15 Claims. (Cl. 74—691)

This invention relates to a mechanical type of infinitely variable speed-changing transmission in which the speed change is obtained by varying the relative positions of adhesion or friction elements and of which some of such elements have planetary movement.

In the known constructions of infinitely variable speed-changing transmissions of the planetary adhesion element type, the planetary elements must be of considerable mass for a number of reasons especially when the axes of such elements are inclined to the axis of the driving shaft. Some of the adhesion elements are subjected to gyrostatic forces which vary dependent on the speed, and produce local reactions disturbing the operation of the device. Reltaively high pressures per unit area of the adhesion contact surfaces, are required for transmitting given amounts of power and such pressures are usually applied to the planetary elements in an unbalanced manner. The planetary adhesion elements are usually relatively closely associated by way of the non-planetary adhesion elements and are therefore considerably affected as a whole by abnormal operation of any one of the planetary elements.

Further, when all of the power flow is taken through the adhesion elements, the quantity of power transmitted is limited to a large degree by the pressures obtainable and sustainable in a practical transmission of the adhesion element type. There is no division and equalization of pressures between a number of adhesion elements in the known constructions and there is no practical manner for transmitting reaction torque to relatively stationary portions of the structure. In the known adhesion type drives, the adhesion members have not been mounted to "float" or adjust themselves as required by the forces involved.

It is therefore an object of the present invention to provide an infinitely variable speed-changing transmission of the planetary adhesion element type in which the planetary elements are of relatively small mass and are subjected substantially to only centrifugal force of which the moment arm is readily varied to obtain varying pressures between the adhesion elements and thus provides a means for changing speed between the input and output shafts.

Another object of the present invention is to provide an infinitely variable speed-changing transmission of the planetary adhesion element type in which the planetary elements provide a large number of surfaces in contact with their mating elements and in such manner that the pressure per unit area of contact is minimized and that the pressures on the planetary elements are balanced and equalized.

Another object of the present invention is to provide an infinitely variable speed-changing transmission of the planetary adhesion element type in which the planetary elements are relatively independent and unaffected by abnormal actions or reactions of other planetary elements.

Another object of the present invention is to provide an infinitely variable speed-changing transmission of the planetary adhesion element type in which only a portion of the power to be transmitted, must flow through the adhesion elements so that a larger quantity of power may be transmitted than would otherwise be possible at a given pressure between the adhesion elements.

Another object of the present invention is to provide an infinitely variable speed-changing transmission of the planetary adhesion element type in which all the adhesion elements are symmetrical and are symmetrically arranged about the longitudinal axis of the device and about an axis at right angles thereto, to minimize vibrations in the device.

Another object of the present invention is to provide an infinitely variable speed-changing transmission of the planetary adhesion element type in which the reaction forces are so transmitted to a stationary portion of the structure as to avoid difficulties in adjusting the transmission to any desired speed ratio and at any point in the speed range.

Another object of the invention is to provide an infinitely variable speed transmission in which adhesion elements are utilized for varying the speed of one shaft and are mounted for self-adjustment and so interconnected as to equalize the pressures between a large number of pairs of contact points.

A further object of the invention is to provide a variable speed transmission in which all adhesion elements are rotatable and the reaction pressures are transmitted to a fixed portion of the structure otherwise than by way of the adhesion elements.

A further object of the invention is to provide a variable speed transmission in which speed variation is obtained by varying the relationship in space of the adhesion elements, and in which the input and output shafts rotate in the same directions and the adhesion elements are therefore subjected only to the difference between the input and output torques.

Another object of the invention is to provide a variable speed transmission in which torque is transmitted through both sides of adhesion rollers by means of rotating adhesion disks.

And a further object of the invention is to provide an infinitely variable transmission employing adhesion elements for variation of speed and in which the adhesion elements are so related that the relationship in space between one set of elements and another set of elements are variable by the application of a force which is only a small fraction of the power transmitted by way of such elements.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawing in which:

Fig. 1 is a view partially in elevation and partially in section on a plane transverse to the axis of the input and output shafts of a transmission embodying the present invention.

Fig. 2 is a view partially in elevation and partially in section along the axis of the input and output shafts of the transmission.

Fig. 3 is a cross-sectional view on the plane 3—3 of Fig. 2; and

Fig. 4 diagrammatically illustrates the path of power flow through a portion of the transmission and the directions of movement or tendency to movement of some of the parts in such transmission and further illustrates the structure of portions of such transmission.

Generally stated, the present structure includes constant and variable speed shafts and in which power is transmitted from the constant speed shaft to the variable speed shaft in an infinitely variable manner within a given range. The constant speed shaft subjects adhesion

rollers to substantially only centrifugal force which is variable as the distance of the rollers from the shaft axis is varied. The rollers severally act at diametrically opposite points on adhesion disks which are adjustable to control the position of the rollers radially of the constant speed shaft and by which the rollers are caused to rotate about their axis as planets. Rotation of the rollers is transmitted to gears receiving the reaction forces and transmitting such forces through a reaction gear to a portion of the structure having only limited movement relative to the housing. The disks are floatingly (self-adjusting) mounted on gearing which equalizes the pressures between the disks and the rollers, and the disks may position themselves relative to the rollers axes as required to maintain equalized pressures between the adhesion elements.

Planetary gearing connects the two shafts and the orbit gear of such gearing is rotatably driven by power received from the adhesion pressure equalizing gearing. Some of the power is thus transmitted by way of the adhesion pressure equalizing gearing but far larger amounts of power are transmitted by way of the planetary gearing and do not pass through the adhesion pressure equalizing gearing. The torque reactions of the transmission are transmitted to bevel gearing and thence to a yoke and from the yoke to the housing. However, because one of the adhesion driving disks rotates, the tangential forces transmitted are small and, since the normal (perpendicular) forces are balanced, the device is easily adjusted. Because both of the disks float or adjust themselves relative to the rollers and hence to each other, the entire reaction portion of the adhesion assembly may be said to be self-adjusting.

Referring to the drawings in which like numerals designate like parts, a housing element **10** provides a side wall, an end wall and a base portion of the housing. The housing end wall portion is formed with a flange **11** of which the purpose appears hereinafter. An open end of the housing element **10** is substantially closed by an end wall **12**, both the end walls of the housing having aligned apertures therethrough. The aperture in end wall **12** receives a plate **13** in which is mounted a bearing **14** for partially supporting a first shaft **15**. The plate **13** also receives a seal **16** for preventing escape of lubrication from the bearing and about the shaft. A cylindrical surface of the plate **13** is splined internally as indicated at **17**.

Shaft **15** has an enlarged portion within the housing and such portion is provided with a plurality of sockets spaced equally about and extending radially of the shaft. The sockets (six being used in the present construction) receive a plurality of stems **22** to extend from the shaft in the manner of the spokes of a wheel. The ends of the stems are joined by a ring **23** thus completing the wheel-like appearance of the structure. Bearings **24** and **25** are mounted on each of the stem-spokes **22** adjacent the shaft **15** and the rings **23**, respectively. The bearings **24** support bevel gears **26** and receive the end thrust of bevel gears **27** which are mounted on the bearings **25**. Both gears **26** and **27** rotate about the axis of shaft **15** and about their respective axles **22**, the axes of such axles being radially of the shaft and in the same plane at right angles to the shaft axis. The gears **27** mesh with a ring gear **28** which is mounted on a comparatively immovable part, and such ring gear causes rotation of gears **27** about their axles **22**.

Gears **27** each have a hub-like extension **29** which encloses portions of the axles **22** and such extensions are externally splined. Rollers **30** are mounted on each of the gear extensions **29** and have internal splines engaging the gear hub external splines so that the rollers may move axially of such extensions and are connected for rotation with gears **27**. The rollers have peripheral surfaces at an angle to the axes thereof and such surfaces are preferably somewhat crowned for frictionally engaging surfaces of other elements of the structure by substantially a line contact and for positioning the rollers dependent upon the positioning of such other elements.

The splined surface **17** of housing plate **13** coacts with a sleeve **35** on the shaft **15** to define a substantially annular space in which a flanged ring **3** is movable axially of the shaft. A peripheral edge of ring **36** is formed with teeth to engage in the splines of plate flange **17** so that the ring **36** is substantially held against rotational movement. The flanges of ring **36** also define an annular space in which is mounted a bearing **37** for rotatably supporting an angle ring **38** having a toothed peripheral edge. A plurality of bearings **41** are mounted on the shaft **15** adjacent the ring **36** to support another flanged ring **42** with a toothed peripheral edge and a bevel gear ring **43** which is preferably fixed to the ring **42**. The ring gear **43** meshes with the bevel pinions **26** on the axles **22** so that the latter pinions have a planetary action.

Referring now to the right hand end of Fig. 2, a bell-like housing member **50** is positioned on the end wall portion of the housing element **10** by means of the housing flange **11** and is fixed on such flange. The housing bell **50** has an aperture aligned with the apertures in the end walls of the housing **10** and receives a bearing **51** partially supporting a shaft **52**, a plate **53** with a seal **54** closing the space about the shaft **52**. The end of shaft **52** within the housing has a socket in which is mounted a bearing **55** receiving the end of shaft **15** within the housing, so that shaft **15** is supported by a plurality of bearings.

Shaft **52** has arms **57** extending at a right angle to the axis of the shaft and such arms support a cylinder **58** from which pins **59** extend radially inwardly, the inward ends of the pins being joined by a ring **60**, the ring being supported by a bearing **65**. Such pins support bearings **61** on which are severally mounted bevel pinions **62**. A flange **63** is keyed to the shaft **15** and has fixed thereon a bevel ring gear **64** meshing with the pinions **62**. A sleeve **67** extends in a spaced relation over a portion of shaft **15** and is supported by bearings **68** and **75** mounted respectively on the shaft **45** and in the end wall portion of housing element **10**. Such sleeve is flanged at one end to support a bevel ring gear **69** also meshing with the pinions **62**. The gears **62**, **64** and **69** form a planetary gear train in which gears **64** and **69** rotate in opposite directions on coincident axes about central gear **62** offset from said axes.

A sleeve **74** is fixed in the aperture of the end wall of housing element **10** and extends about the sleeve **67** and is formed with external splines for engaging the internal splines of an angle ring **76**. The angle ring **76** is externally threaded and supports a bearing **77**. A yoke is formed as a hollow ellipsoid to provide two leg portions **78** and **79** with a peripheral portion at least partially threaded as indicated at **80**. The yoke legs are apertured and flanged and internally threaded to engage with threads on the angle rings **36** and **76**, such threads being right and left-hand threads. The peripheral yoke thread **80** forms at least a portion of a worm wheel engageable with a worm **81** mounted in bearings **82** and **83** in the housing element **10**.

A pair of generally conical disks **88**, **89** is provided with central apertures severally defined by flange-like extensions and the disks are mounted to define a space within which the set of rollers **30** operates. The adjacent surfaces of the disks are at the same angle to the plane through the axes of the rollers as the peripheral friction surfaces of the rollers. The disks are of such diameter that the roller friction surfaces are always in contact with the adjacent disk surfaces, even though the rollers move outwardly from the position designated B (see Fig. 4) to the position A. The internal surfaces of the disk apertures are splined, the splines of disk **88** engaging the splines on the angle rings **38** and **42**, the

splines of the ring **38** being restricted in their movement relative to the disk splines by snap rings **90** inserted in grooves in the disk at both sides of the ring **38**. Hence, as angle ring **38** is moved axially of the shaft **15**, the disk **88** moves with the ring and the disk slides on the splines of gear ring **42**.

A bevel gear ring **93** is keyed to the sleeve **67** and is supported on bearing **94** seated on sleeve **74**, for rotation of the gear ring **93** relative to the fixed sleeve **74**. The gear ring **93** is externally splined for slidably engaging with the splines of disk **89** as such disk moves axially of shaft **15**. Disk **89** is also supported on the bearing **77** for rotation relative to the shaft and such bearing is held on the angle ring **76** so that the disk **89** moves axially of the shaft as the angle ring **76** is rotated.

In operation, it is assumed that the shaft **15** is operating at a constant speed of 1800 R. P. M. and that the speed of shaft **52** is to be varied continuously from zero speed to a maximum, the maximum speed of the shaft **52** being dependent on the ratio of the gearing employed and being 630 R. P. M. in the present instance. For standstill or zero speed of the shaft **52**, worm **81** is rotated to move yoke **78, 79, 80** in a direction to thread rings **36, 76** toward each other. Such rings act respectively through bearing **37** on angle ring **38** and through bearing **77** on the disks **88** and **89** to force the disks toward each other. The adjacent surfaces of the disks press on the friction surfaces of rollers **30** and exert a wedging action on the rollers to retain the rollers in the position shown, namely, position B. Such wedging action is the result of the additive effect of movement of pairs of screw threads so that little force is required to secure the necessary roller-disk pressures.

The rollers **30** move around the axis of the shaft **15** as the shaft rotates and are therefore under the action of centrifugal force of a value depending on the length of the moment arm from the axis of the shaft to the line of contact of the roller crowned surfaces **30** with the surfaces of disks **88, 89**. Rotation of shaft **15** turns spokes **22** relative to ring gear **28** thereby rotating gears **27** and rollers **30** splined thereto.

The total pressure between the set of rollers **30** and the set of disks **88, 89** is divided into twelve parts but may be further divided if desired, by increasing the number of rollers. Such pressure provides the necessary traction effort to transmit the torque on the disks **88, 89** which is equalized by connection of the disks by way of the equalizing gearing **42, 43, 26** and **93**. Torque is transmitted from the disks by way of the equalizing gearing to the sleeve **67** which drives the gear **69**. Hence, the speed at which the shaft **52** is driven depends only on the ratio of the planetary gearing **62, 64, 69** and the speed at which gear **69** is driven by sleeve **67**.

The driving forces react from the adhesion elements **30, 88** and **89** to the planet bevel pinion **27** to the bevel gear **28** and thence through the yoke **78, 79, 80** to the worm **81** and the housing. Hence, the adhesion disks are not subjected to high reaction forces.

In position B rollers **30** act on a relatively small circumference of disk **89** to counterrotate sleeve **67** at high speed substantially equal to the speed of shaft **15**. Thus gears **63** and **69** are counterrotated at the same speed and pins **59** and shaft **52** are stationary.

To achieve maximum speed of shaft **52**, the rollers **30** must be allowed to move from position B to position A where the circumference of the disk **89** is greatest, it being understood that speeds between zero and maximum of the output shaft are obtained in the positions of the rollers between B and A in proportion to the circumference of disk **89** where it is contacted by rollers **30**. The yoke **78, 79, 80** is now moved to allow the disks **88, 89** to separate so that the centrifugal force on the rollers will move the rollers to position A. At position A, the rollers act on the greatest circumference of disk **89**. Thus sleeve **67** is driven at relatively slow speed counter to

shaft **15**. Thus pins **59** and shaft **52** are driven in the same direction as shaft **15** but at lower speed, dependent on the ratio of the gearing connecting the shafts. Thus, for the proportions indicated in the drawings, for the output shaft to rotate at 630 R. P. M. or more, bevel gear **69** and sleeve **67** must counterrotate at a speed of 540 R. P. M. and when the output shaft is to be at standstill, bevel gear **69** and sleeve **67** must counterrotate at the maximum speed of 1800 R. P. M. (full input speed).

It will be seen that the present construction provides a housing **10** with a side and end wall element from which may be overhung a housing bell **50**, and on which is fixed a removable end wall **53**. A first shaft **15** extends into the housing **10** and has a plurality of spoke-like or radially arranged members **22** with their axes in the same plane. Means formed as externally splined gears **27** are severally mounted on the radial members **22** for rotation therewith about the axis of the first shaft and for rotation relative to the members. Rollers **30** with adhesion or friction surfaces are splined on the gears **27** for movement axially thereof and hence radially of the first shaft to vary the points of contact of rollers **30** with the disk **89**. A pair of disks **88, 89** alongside the rollers coacts with the rollers **30** to provide a plurality of pairs of contact surfaces and such disks **88, 89** may be adjusted as to axial spacing to allow centrifugal force movement of the rollers away from the axis of the first shaft or to force such rollers toward such axis.

The disks are movable axially of the first shaft by angle rings **38, 76**. The rings **38, 76** are movable axially relative to the housing **10** and are rotatably mounted. A yoke **78, 79** threadedly engages the angle rings **36, 76** and the housing **10** for adjustment of the rings and the disks and to transmit the reaction forces to the housing. Such torque reaction forces are transmitted from the splined gears to a bevel gear ring **28** on the yoke.

Even though the yoke **78, 79** and the angle rings **36, 76** are threadedly engaged, at least one of the rings has a dental coupling connection **17** which permits it to "float" or adjust itself as required by the normal and tangential forces acting on the disks to the end that such forces are equalized. The disks are further severally supported by way of dental couplings **42** with two gear rings **43** and **93** rotatable relative to the shaft and such gear rings **43, 93** are joined by idler pinions **26** severally mounted on the axles **22** extending radially from the first shaft. The gear rings and idler pinions **26** equalize the tangential forces acting between the rollers **30** and the disks **88, 89** and the torque exerted on said disks is transmitted by said disk **89** to sleeve **67** concentric with shaft **15**. The normal (perpendicular) pressures acting on the rollers **30** and disks **88, 89** are balanced by "floating" or self-adjustment of the disks axially of the device as aforesaid. The sleeve **67** is rotatably supported in the housing and aids in rotatably supporting the first shaft **15** relative to the housing and the sleeve.

A second shaft **52** is rotatably supported in the housing bell **50** and at the end of the first shaft **15**. The two shafts are joined by planetary gearing comprising a ring gear **64** fixed to shaft **15**, a ring gear **69** fixed to sleeve **67** and orbit gears **62** mounted between the ring gears on pins **59** journaled in cylinder **58**. The preponderance of the power flows through the planetary gearing **64, 62, 69** and only a minor portion of the power flows through the pressure equalizing gearing and the adhesion elements in housing **10**. The planetary gearing has the effect of extending both the quantity of power transmissible and the range of speed ratios obtained when the one shaft is driven at constant speed and the other shaft is driven at variable speed, as compared to other mechanical type variable speed devices now known.

The present construction utilizes planetary adhesion rollers **30** which are of relatively small mass and have axes at right angles to the shaft driving the rollers. A

considerable number of rollers are clustered uniformly and relatively closely around the drive shaft and the rollers are subjected both to centrifugal force and to rotative thrust. The spacing of disks **88, 89** and centrifugal force acting on the rollers **30** dictate the circumference of the disks on which the rollers ride and thus determine speed of the sleeve **67** and thereby the speed of shaft **52**. The disks **88, 89** contact the rollers **30** at diametrically opposite points so that the pressures on each of the rollers **30** are balanced. The disks **88, 89** are interconnected and are mounted for self-adjustment to equalize pressures of the rollers on the disks. The reaction torques are transmitted from disks **88, 89** directly to the housing. Both the first and the final second shaft rotate in the same direction, counter to the direction of rotation of sleeve **67**, so that the reaction torque of the drive as a whole is the difference between the input torque and the output torque.

Only a fraction of the power transmitted need pass through the speed-changing adhesion elements in housing **10**, the major portion of the transmitted power flowing through the first shaft **15** and the gearing **64, 62, 69** to the second shaft **52**. Therefore, in addition to infinite variation of the speed within the range for which the parts are proportioned, the present device has the advantages of long life with minimum maintenance, and a largely increased power transmission capacity as compared with the prior planetary adhesion type speed-change devices.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent that various changes and modifications may be made therein without departing from the invention as defined in the appended claims.

I claim:

1. In a device for transmitting power at an infinitely variable speed ratio between input and output shafts, a first shaft, a plurality of adhesion elements in mutual contact and rotatably driven by the first shaft, means for varying the point of contact of one element against another, means for sustaining the reaction torque between the elements, means for reacting on the adhesion elements and providing a path for a portion of the power transmitted, a second shaft, and planetary gearing for joining the first and second shafts for transmitting a portion of the power therebetween and for receiving the portion of the power transmitted by the reacting means, the speed ratio of the shafts varying as the point of contact of the adhesion elements is varied.

2. In a device for transmitting power at an infinitely variable speed ratio between input and output shafts, a first shaft, a plurality of spoke-like members extending radially from the first shaft, a plurality of rollers severally mounted on the spoke members and movable radially of the first shaft under the action of the centrifugal force exerted thereon by shaft rotation, a pair of disks supported on for rotation about the first shaft at opposite sides of said spoke-like members and frictionally engaged with said rollers, means for adjusting the radial position of the rollers to vary the circumferential point of engagement of the rollers with the disks, means for sustaining the reaction torque between the disks, means for reacting on the rollers and disks and providing a path for a portion of the power transmitted, a second shaft, and planetary gearing for joining the first and second shafts for transmitting a portion of the power therebetween and for receiving the portion of the power transmitted by the reacting means, the speed ratio of the shafts varying as the radial position of the rollers respecting the disks is varied.

3. In a device for transmitting power at an infinitely variable speed ratio between input and output shafts, a housing, a first shaft, a plurality of spoke-like members extending radially from the first shaft, rollers severally mounted on the members and movable radially of the shaft axis, a pair of disks supported for axial movement thereon and rotatable relative to the shaft members for engaging the rollers at opposite sides of the spoke-like members, a yoke rotatably adjustable relative to the shaft and engaged with the housing, the yoke controlling the axial position of the disks and the radial position of the rollers, said yoke comprising means for sustaining the reaction torque between the rollers and disks, means for reacting on the rollers and disks and providing a path for a portion of the power transmitted, a second shaft, and planetary gearing for joining the first and second shafts for transmitting a portion of the power therebetween and for receiving the portion of the power transmitted by the reacting means, the speed ratio of the shafts varying as the radial and axial positions of the rollers and disks is varied.

4. In a device for transmitting power at an infinitely variable speed ratio between input and output shafts, a housing, a first shaft, a plurality of spoke-like members extending radially from the shaft and with their axes in the same plane, fixed gear means concentric with said first shaft, gear means on said members meshing with said fixed gear means to be rotated as said first shaft is turned, rollers severally rotatable on the members and splined to the gear means mounted on the members for radial movement on said members, a pair of disks supported for axial movement and rotatable relative to the shaft and frictionally engaged with the rollers, said disks being inclined with respect to the axis of roller rotation, a yoke rotatably adjustable relative to the shaft and engaged with the housing, the yoke controlling the axial position of the disks and radial position of the rollers and sustaining the reaction torque between the disks and the rollers, means for reacting on the rollers and disks and providing a path for a portion of the power transmitted, a second shaft, and planetary gearing for joining the first and second shafts for transmitting a portion of the power therebetween and for receiving the portion of the power transmitted by the reacting means, the speed ratio of the shafts varying as the axial position of the disks and radial position of the rollers is varied.

5. In a device for transmitting power at an infinitely variable speed ratio between input and output shafts, a housing, a constant speed shaft, spoke-like members extending radially from the shaft, gears mounted on the spoke-like members for rotation thereabout, the gears having hub extensions externally splined, rollers severally mounted on the splined extensions of the gears, a pair of disks supported for rotation relative to the shaft for engaging the several rollers on a given circumference of the disks, a yoke rotatably adjustable relative to the shaft and engaged with the housing, a circular rack mounted on the yoke for meshing with the said gears whereby to turn said rollers when the constant speed shaft is turned, means for reacting on the rollers and disks and providing a path for a portion of the power transmitted, a second shaft, and planetary gearing for joining the first and second shafts for transmitting a portion of the power therebetween and for receiving the portion of the power transmitted by the reacting means, said rollers being mounted for radial movement on said members whereby to vary the point of circumferential engagement of said rollers with said disks, the speed ratio of the shafts varying as the point of circumferential engagement of the rollers and disks is varied.

6. In a device for transmitting power at an infinitely variable speed ratio between input and output shafts, a first speed shaft, a plurality of first adhesion elements mounted for radial movement and subject to centrifugal force of shaft rotation, means for rotating said elements, a plurality of second adhesion elements rotatably supported relative to the shaft and frictionally engaged with the first adhesion elements, said second elements being inclined to the radial path of said first elements whereby axial movement thereof is necessary to permit radial movement of the

first elements, means for adjusting the axial positions of the second adhesion elements and thereby controlling the centrifugal position of the first adhesion elements on said radial path, means for reacting on the adhesion elements and providing a path for a portion of the power transmitted, a second shaft, and planetary gearing joining the first and second shafts, one portion of the gearing being driven by the reacting means and another portion of the gearing being driven by the constant speed shaft, the speed of the second shaft varying as the radial position of the first adhesion elements varies relative to the first shaft.

7. In a device for transmitting power at an infinitely variable speed ratio between the input and output shafts, a constant speed shaft, a first set of adhesion elements rotated by the shaft and subjected to centrifugal force thereby, the first adhesion elements being movable radially of the shaft, a second set of adhesion elements rotatably supported relative to the shaft and frictionally engaged with the first adhesion elements, the second adhesion elements being movable axially of the shaft, means for adjusting the positions of the second adhesion elements and for controlling the position of the first adhesion elements relative to the axis of the shaft, means for reacting on the sets of adhesion elements and for forming a path for transmission of a portion of the power through the device, a variable speed shaft, a gear connected with the reacting means and rotated thereby, a gear connected with the constant speed shaft, and a plurality of planet gears mounted on the variable speed shaft, the planet gears meshing with the gears aforesaid and transmitting power between the shafts.

8. In a device for transmitting power at an infinitely variable speed ratio between the input and output shafts, a housing, a constant speed input shaft, a plurality of members extending radially from the shaft with their axes in the same plane, gears severally mounted on the shaft members, the gears having hub extensions externally splined, a plurality of rollers severally mounted on the splined gear extensions for movement radially of the shaft, a pair of disks adjustably supported alongside the rollers and severally engaging with each of the rollers, means for reacting on the disks, a yoke rotatably adjustable relative to the input shaft and engaged with the housing for moving the disks toward and away from each other and thereby varying positions of the rollers relative to the shaft axis and circumference of the discs contacted by the rollers, a rack or bevel gear fixed on the yoke and meshing with the shaft-member-mounted gears for rotating said gear and for transmitting reaction forces to the housing, a variable speed output shaft, the distance of the rollers from the input shaft axis varying the speed of the output shaft, and planetary gearing joining the input and output shafts for transmitting power therebetween, the planetary gearing comprising a gear driven by the means for reacting on the disks, a gear driven by the input shaft, and planet gears mounted on the output shaft for meshing with the gears aforesaid.

9. In a device for mechanically transmitting power at an infinitely variable speed ratio, the combination of an input shaft, an output shaft, a friction drive means comprising a pair of coaxial rotary disks in opposed and spaced relation, a set of rollers driven by the input shaft and arranged between the disks and in frictional engagement therewith for rotation about the disk axis, and means reacting on the rollers to impart planetary motion thereto for effecting rotation of the disks in opposite directions, the rollers being adjustable radially of the disks for varying the speed ratio between the input and output shafts, and planetary gearing driven by the input shaft and the friction drive means for driving the output shaft at speeds dependent on coaction of the disks and rollers.

10. In an infinitely variable speed transmission of the mechanical type, the combination of a first shaft and a second shaft, a speed changer including a non-rotary gear and a pair of opposed disks rotatable about the first and second shafts in opposite directions and adjustable axially thereof and a set of planetary rollers in rolling engagement with and between the disks, adjustment of the disks controlling positioning of the rollers radially of the disks, the rollers reacting on the non-rotary gear, means for moving the disks together and apart for controlling radial positioning of the rollers, and planetary gearing driven by the speed changer and connecting the first and second shafts for transmitting power therebetween.

11. In a variable speed transmission, the combination of coaxial driving and driven shafts, a friction drive means comprising a pair of opposed and oppositely rotating disks coaxial with the shafts, a set of planet rollers in pressure engagement with and between the disks, and a rotary carrier for the rollers and driven by one of the shafts, means including a non-rotary ring gear reacting on the rollers to control the planetary action thereof, the rollers being movable radially of the disks to vary the rate of rotation of the disks, and planetary gearing connecting the driving and driven shafts and responsive to variations in the rate of rotation of the disks to vary the speed ratio between the two shafts.

12. In a device for mechanically transmitting power at an infinitely variable speed ratio, a first shaft, a second shaft, a speed changer including coaxial opposed disks rotatable in opposite directions, and planet rollers rotating about the first shaft and coacting with the disks as an adhesion drive, rotation of the rollers about their own axes being in fixed relation with rotation of the rollers about the first shaft axis, and planetary gearing connecting the rollers with the first shaft through said speed changer and connecting the first and second shafts whereby only a portion of the transmitted power flows through the speed changer.

13. In a device for mechanically transmitting power at an infinitely variable speed ratio, a first shaft, a second shaft, first planetary gearing connecting the first and second shafts for transmission of a portion of the power flow therebetween, a speed changer including rotatable disks and planet rollers coacting therewith and connected with said first planetary gearing, and second planetary gearing connecting the first shaft with the first planetary gearing and with the speed changer whereby another portion of power flows through the speed changer and through the first planetary gearing to the second shaft.

14. In a device for transmitting power at an infinitely variable speed ratio, a first shaft, a second shaft, a friction means drive comprising a plurality of first adhesion elements mounted on the first shaft for rotating the first adhesion elements upon rotation of the first shaft, the first adhesion elements being subjected to centrifugal force for movement thereof radially of the first shaft, a plurality of second adhesion elements extending radially of and rotatably supported relative to the first and second shafts and frictionally engaged with the first adhesion elements, and means for adjusting the positions of the second adhesion elements axially of the first shaft and for controlling the position of the first adhesion element radially of the first shaft, means for reacting on the adhesion elements and providing a portion of a path for a portion of the power transmitted, and planetary gearing connecting the first and second shafts for transmitting the said portion of the power, the speed ratio of the first and second shafts varying as the radial position of the first adhesion elements is varied.

15. In a device for transmitting power at an infinitely variable speed ratio, a housing, a first shaft, a second shaft, a friction drive means comprising a plurality of adhesion elements rotatably driven by the first shaft, one of said elements comprising a driver radially movable with respect to the first shaft and another of said elements comprising a driven element axially movable with respect to the first shaft, a yoke adjustable relative

to the first shaft and engaged with the housing for controlling the axial position of the driven element and the radial position of the driver element, and means for sustaining the torque reaction between the driver and the driven elements, means for reacting on the adhesion elements and providing a portion of a path for a portion of the power transmitted between the first and second shafts, and planetary gearing connecting the first and second shafts for transmitting the said portion of the power flowing through the first mentioned means, the speed ratio of the first and second shafts varying as the

axial and radial relationship of the adhesion elements is varied.

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